

AIR QUALITY MONITORING CONSIDERATIONS FOR THE SONORAN DESERT NETWORK

November 2001

Introduction

The NPS Air Resources Division (ARD) has contracted with the University of Denver (DU) to produce GIS-based maps that estimate baseline values (with confidence limits) for a set of air quality parameters for all Inventory and Monitoring parks in the U.S. This information will be available in late FY 2001. ARD used preliminary DU products to help develop an implementation strategy for expanding NPS air quality monitoring under the Natural Resources Challenge and determined that we do not intend to install new monitoring in Sonoran Desert Network parks in FY 2002 or FY 2003. The air monitoring implementation strategy will be revisited in FY 2004 if additional funding becomes available. The Sonoran Desert Network can use the final DU products (which will be sent to you when available), along with on-site and/or nearby off-site ambient monitoring and natural resource data discussed in this report, to help assess air quality-related conditions and monitoring needs in Network parks.

Wet Deposition

Six of the 11 NPS units in the Sonoran Desert Network have a National Atmospheric Deposition Program/National Trends Network (NADP/NTN) wet deposition monitor on-site or within 100 km (60 miles). These units are Chiricahua National Monument (NM), Coronado National Memorial (NMem), Fort Bowie National Historic Site (NHS), Gila Cliff Dwellings NM, Organ Pipe Cactus NM, and Saguaro National Park (NP). NADP/NTN collects data on both pollutant deposition (in kilograms per hectare per year) and pollutant concentration (in microequivalents per liter). Deposition varies with the amount of annual on-site precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount, therefore, it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years. In general, wet deposition and concentration of sulfate, nitrate, and ammonium are relatively low compared to most NADP/NTN sites in the United States (see U.S. wet deposition isopleth maps at <http://nadp.sws.uiuc.edu>). Data from the five NADP/NTN sites in Arizona and southwest New Mexico are summarized below.

Chiricahua NM

An NADP/NTN site was installed at Chiricahua NM (site #AZ98) in 1999. Sufficient data are not yet available to perform a trend analysis for this site.

Gila Cliff Dwellings NM

Gila Cliff Dwellings NM (site #NM01) has had a NADP/NTN site since 1985. Wet sulfate concentration and deposition have decreased at the site, which is consistent with a nationwide decrease in sulfur emissions. While there has been no apparent trend in nitrate deposition, nitrate concentration has increased, as have both deposition and concentration of ammonium.

Grand Canyon NP

The NADP/NTN site at Grand Canyon NP (site #AZ03) has been operating since 1981. A review of site data shows concentration and deposition of wet sulfate have decreased. Wet deposition of ammonium and nitrate shows no overall trend, but there has been a slight increase in concentrations of both pollutants.

Oliver Knoll

The Oliver Knoll NADP/NTN site (site #AZ99), located in Graham County and operated by the Bureau of Land Management, has been in operation since 1981. Site data show a decrease in wet sulfate concentration and deposition. Wet deposition of ammonium and nitrate shows no apparent trend, but there has been an increase in wet ammonium and nitrate concentration in precipitation.

Organ Pipe Cactus NM

The NADP/NTN site at Organ Pipe Cactus NM (site #AZ06) has been operating since 1980. Site data indicate a decrease in concentration and deposition of wet sulfate; no obvious trend in concentration of wet ammonium, deposition of wet ammonium, or deposition of wet nitrate; and a slight increase in concentration of wet nitrate.

There is currently no NADP/NTN monitor in central Arizona. Based solely on spatial distribution, it appears installing a monitor at Tonto NM would provide wet deposition data for Tonto NM and Casa Grande Ruins NM. In addition, the data could be combined with those collected at Grand Canyon NP to better assess conditions at Montezuma Castle NM and Tuzigoot NM. The DU analysis discussed above will provide better information on the adequacy of existing wet deposition monitoring, and identify holes in the current NADP/NTN network. A NADP/NTN wet deposition site costs \$5,000 to \$8,000 for equipment purchase and installation, and operating costs (including site operation, chemical analysis, and reporting) are about \$7,000 per year.

Dry Deposition

Four of the 11 units in the Sonoran Desert Network have a Clean Air Status and Trends Network (CASTNet) dry deposition monitor on-site or within 100 km. These units are Chiricahua NM, Coronado NM, Fort Bowie NHS, and Saguaro NP. CASTNet uses different monitoring and reporting techniques than NADP/NTN, so the dry deposition amounts are reported as nitrogen and sulfur. In addition, because CASTNet calculates dry deposition based on measured ambient concentrations and estimated deposition velocities, there is greater uncertainty in the reported values. Due to the small number of CASTNet sites, use of dry deposition isopleth maps is not advised at this time. CASTNet data collected at the two sites in Arizona are summarized below.

Chiricahua NM

The Chiricahua NM CASTNet site (site #CHA467) has been operating since 1989. A review of the site data shows no apparent trend in dry nitrogen or sulfur deposition. Based on a comparison of CASTNet and on-site NADP/NTN data, CASTNet estimates total deposition of both nitrogen and sulfur at Chiricahua NM consists of 65 percent wet deposition and 35 percent dry deposition.

Grand Canyon NP

The CASTNet site at Grand Canyon NP (site #GRC474) has been operating since 1989. The site data show no apparent trend in dry nitrogen or sulfur deposition. Based on a comparison of CASTNet and on-site NADP/NTN data, CASTNet estimates total deposition of nitrogen at Grand Canyon NP consists of 63 percent wet deposition and 37 percent dry deposition, while total sulfur deposition is 76 percent wet and 24 percent dry.

Based solely on spatial distribution of CASTNet sites, it appears that not all parks in the Sonoran Desert Network have representative dry deposition data. However, given that the ratio of wet to dry deposition is comparable for the Chiricahua NM and Grand Canyon NP sites, as long as wet deposition coverage is adequate for the Network, it may be possible to estimate dry deposition. If collection of additional dry deposition data is desirable, Organ Pipe Cactus NM is a high priority site because 1) it is a large park with significant natural resources, and 2) of all the Sonoran Desert Network parks, Organ Pipe Cactus NM is the greatest distance from an existing CASTNet dry deposition site. Installation and annual operating costs for a CASTNet site are about \$50,000 and \$15,000, respectively.

Surface Water Chemistry

The Water Resources Division's *Baseline Water Quality Data Inventory and Analysis* reports were reviewed for 10 of the 11 NPS units in the Sonoran Desert Network. In most cases, in-park data were quite limited and were a number of years old. Acid-sensitive surface waters typically have specific conductance below 25 microseimens per centimeter ($\mu\text{S}/\text{cm}$), a pH below 6.0 and an acid neutralizing capacity (ANC) below 100 microequivalents per liter ($\mu\text{eq}/\text{l}$). With the exception of a couple of springs in Saguaro NP, all the data indicated sampled surface waters were not sensitive to atmospheric deposition. Two springs at Saguaro NP had conductivity values of 25 $\mu\text{S}/\text{cm}$, suggesting potential sensitivity. Further sampling is needed, with additional water quality parameters, to assess the sensitivity of those springs. For some monuments, data were over 20 years old and/or did not adequately represent the suite of water resources in the unit. Network staff should evaluate the adequacy of those data and determine if additional data collection is warranted. Data from the *Baseline Water Quality Data Inventory and Analysis* reports for Sonoran Desert Network parks are summarized below.

Casa Grande Ruins NM

A review of the 2000 *Baseline Water Quality Data Inventory and Analysis* report for Casa Grande Ruins NM indicated no water quality data have been collected in the monument. Data collected from three streams outside the monument showed average pH values of 7.4 to 9.0 and average ANC values of 552 to 1120 $\mu\text{eq}/\text{l}$. While the data indicate these streams are well buffered, and so, are not sensitive to acidification from atmospheric deposition, the data do not adequately represent surface water resources in Casa Grande Ruins NM.

Chiricahua NM

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Chiricahua NM indicated seven springs in the monument were sampled between 1960

and 1980. Most were sampled only one time. The springs had conductivity values that ranged from 200 to 1400 $\mu\text{S}/\text{cm}$. The few pH values ranged from 7.0 to 7.5. If these sites are representative of surface waters in the monument, then surface waters of Chiricahua NM are not sensitive to acidification from atmospheric deposition.

Coronado NMem

A review of the 2000 *Baseline Water Quality Data Inventory and Analysis* report for Coronado NMem indicated six of 13 sampling stations were located inside the park. Historic mining and quarrying operations in the park contributed to extremely low pH values and elevated metal concentrations at some sites. Single samples at three springs in the park collected between 1965 and 1993 had pH values of 7.5 to 8.0. Sampling of the San Pedro River outside the park in 1977 showed an average pH value of 7.7 and an average ANC of 504 $\mu\text{eq}/\text{l}$. If these sites are representative of surface waters in the park, then surface waters of Coronado NMem are not sensitive to acidification from atmospheric deposition.

Fort Bowie NHS

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Fort Bowie NHS indicated single samples were collected at six springs in the monument in either 1965 or 1968. The springs had pH values of 7.1 or 7.2. If these sites are representative of surface waters in the monument, then it is unlikely surface waters of Fort Bowie NHS are sensitive to acidification from atmospheric deposition.

Gila Cliff Dwellings NM

A review of the *Baseline Water Quality Data Inventory and Analysis* report for Gila Cliff Dwellings NM indicated only two sites had been sampled in the monument. A spring sampled in 1962 had a pH of 7.0 and an ANC of 832 $\mu\text{eq}/\text{l}$. The West Fork of the Gila River was sampled between 1967 and 1978. The average pH was 7.8, with a minimum value of 7.5. The average ANC was 408 $\mu\text{eq}/\text{l}$, with a minimum value of 232 $\mu\text{eq}/\text{l}$. If these sites are representative of surface waters in the monument, then surface waters of Gila Cliff Dwelling NM are not sensitive to acidification from atmospheric deposition.

Montezuma Castle NM

A review of the 1995 *Baseline Water Quality Data Inventory and Analysis* report for Montezuma Castle NM indicated Wet Beaver Creek was sampled between 1956 and 1991. The samples had an average pH value of 7.2 and an average ANC of 473 $\mu\text{eq}/\text{l}$. Springs sampled outside the monument had an average ANC of 290 $\mu\text{eq}/\text{l}$. These data indicate surface waters in the monument are not sensitive to acidification from atmospheric deposition.

Organ Pipe Cactus NM

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Organ Pipe Cactus NM indicated water quality samples had been collected at 24 sites in the monument, most in the Quitobaquito area. All of the data were collected before 1983. Samples from springs, streams, and Quitobaquito pond had pH values of 7.3 to 8.9 and

ANC values of 1608 to 8400 $\mu\text{eq/l}$. These data indicate surface waters in the monument are not sensitive to acidification from atmospheric deposition.

Saguaro NP

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Saguaro NP indicated seven springs in the Rincon Mountain Unit of the park were sampled once in 1981. Conductivity values ranged from 25 to 320 $\mu\text{S/cm}$. Italian Spring and Manning Camp Spring had conductivity values of 25 $\mu\text{S/cm}$. Unfortunately, pH and ANC were not measured. It would be necessary to collect new samples at these springs, with additional water quality parameters, to further evaluate the sensitivity of the springs to acidification from atmospheric deposition. Samples collected from streams and the Santa Cruz River outside the park indicated the streams and river are not sensitive to atmospheric deposition.

Tonto NM

A review of the 1998 *Baseline Water Quality Data Inventory and Analysis* report for Tonto NM indicated limited water quality data are available for the monument. Monument Spring was sampled once in 1986 and had a pH value of 7.7. Three locations at Cholla Spring and one at Cooper Tank were sampled once in 1980 and had conductivity values ranging from 420 to 540 $\mu\text{S/cm}$. These limited data indicate surface waters in the monument are not sensitive to acidification from atmospheric deposition.

Tuzigoot NM

A review of the 1999 *Baseline Water Quality Data Inventory and Analysis* report for Tuzigoot NM indicated water quality was sampled in the Verde River, Tavasci Marsh Wash, and some springs between 1959 and 1988. Some extremely low pH values were apparently associated with mine drainage. Samples collected in the Verde River had pH values of 8.1 to 8.4, with ANC values of 1900 $\mu\text{eq/l}$ or greater (ANC values were higher near mine seepages). A single sample from Tavasci Marsh Wash in 1979 showed a pH value of 7.7 and an ANC of 2400. Springs had pH values of 7.3 to 7.7 and ANC values of 1700 to 2300. These data indicate surface waters in the monument are not sensitive to acidification from atmospheric deposition.

Visibility

Visibility-impairing particles and certain gases are monitored in natural areas through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. Because of the mandates of the Clean Air Act, the IMPROVE program has focused monitoring efforts in Class I air quality areas. Regardless, IMPROVE monitoring provides a regional analysis of visibility; therefore, the data indicate conditions in nearby Class II air quality areas. Thanks to a cooperative effort between state and federal agencies, Arizona has a large number of existing IMPROVE sites, and additional sites will be added in the next few months. Long term sites include: Chiricahua NM (site #CHIR1), operated since 1988; Gila Cliff Dwellings NM (site #GICL1), operated since 1994; Grand Canyon NP (site #GRCA1), operated since 1989; Saguaro NP – east unit (site #SAGU1), operated since 1988; and Tonto NM (site #TONT1), operated since 1988. New sites have been/will be installed at Organ Pipe Cactus NM (site #ORPI1) and

Saguaro NP – west unit (site #SAGU2), in addition to three U.S.D.A. Forest Service sites at Ike's Backbone in the Prescott National Forest (NF) (site #IKBA1), Queen Valley in the Tonto NF (site #QUVA1), and Sycamore Canyon in the Kaibab NP (site #SYCA1). Therefore, all 11 units of the Sonoran Desert Network will have representative visibility data. IMPROVE program staff recently identified an error in past data calculations, and are in the process of re-calculating the data. Therefore, trend data are not currently available for IMPROVE sites.

Ozone

Only two of 11 units in the Sonoran Desert Network have on-site ozone monitoring, Chiricahua NM (site #040038001) and Saguaro NP (site #040190021). Because of its proximity, the ozone monitor at Chiricahua NM probably provides representative data for Fort Bowie NHS. It is unclear if the remaining eight units have representative data since the closest ozone monitors are either located more than 50 km (30 miles) away or are located in urban areas. It is also not clear if a single monitor can adequately represent ozone conditions for a large or topographically complex park. The results of the DU project will help address these issues. Installation and annual operating costs for an ozone-monitoring site are about \$90,000 and \$14,000, respectively.

Vegetation

For vegetation, the focus is on ozone sensitivity because 1) ozone is a regional pollutant and is, therefore, more likely to affect park resources than either sulfur dioxide or nitrogen oxide which quickly convert to other compounds, and 2) the literature on ozone sensitivity is more recent and more reliable than that for other pollutants. Unfortunately, not much is known about the ozone sensitivity of southwestern U.S. species. Park vascular plant lists contained in a May 2001 version of NPSpecies were compared to the general ozone-sensitive plant species lists contained in the NPS Synthesis information management system (see attached Synthesis species lists). The Synthesis lists were developed by an expert in the field of ozone effects on vegetation. Note that the Synthesis lists are a general guide to ozone sensitivity. Differences in plant genetics, weather conditions, water availability, and ozone concentrations will affect whether or not a species exhibits injury in a particular park. Ozone sensitive species were identified for nine of the 11 units in the Sonoran Desert Network (see attached table of sensitive species for Network parks). Note that according to NPSpecies, there is no data verifying that any of these species occur in the parks.

It is generally agreed that plant foliar injury occurs after a cumulative exposure to ozone. One ozone statistic that is used to evaluate the risk of plant injury is the SUM06. SUM06 is the sum of all hourly average ozone concentrations greater than or equal to 0.06 parts per million (ppm). In 1997, a group of ozone effects experts recommended 3-month, 8:00 a.m. to 8:00 p.m., SUM06 effects endpoints for natural vegetation, *i.e.*, 8 to 12 ppm-hrs for foliar injury to natural ecosystems and 10 to 15 ppm-hrs for growth effects on tree seedlings in natural forest stands. The DU products will give some indication of the ozone risk to sensitive vegetation in Sonoran Desert Network parks. Note that the SUM06 recommendations were based primarily on vegetation in the southeastern United States. Southeastern U.S. species typically have plenty of available soil water, so plant

stomates are open for long periods--allowing for increased ozone uptake. Research suggests plants that grow in drier climates take in less ozone through their stomates, and therefore, can tolerate higher ozone exposures. If ozone concentrations indicate potential foliar injury of vegetation, Network staff may want to conduct a pilot study of foliar injury on one or two species before committing to an extensive monitoring effort.

Conclusions

Six of the 11 NPS units in the Sonoran Desert Network have a NADP/NTN wet deposition monitor on-site or within 100 km. It may be desirable to install a wet deposition monitor at Tonto NM to increase coverage in central Arizona.

There are only two CASTNet dry deposition monitors in the area. It may not be necessary to install additional CASTNet sites if representative wet deposition data are available. If additional dry deposition data are desired, Organ Pipe Cactus NM is a high priority site.

With the exception of a couple of springs in Saguaro NP, all data contained in *Baseline Water Quality Data Inventory and Analysis* reports for Sonoran Desert Network parks indicated sampled surface waters were not sensitive to acidification from atmospheric deposition.

Existing and planned IMPROVE monitors will provide adequate coverage for all 11 Sonoran Desert Network parks.

It is unclear if current ozone monitors adequately represent conditions in all Sonoran Desert Network parks. The DU project will address this issue.

Ozone sensitive species have been identified for nine of the 11 units of the Sonoran Desert Network. Typically, desert vegetation can tolerate relatively high ozone concentrations, however, limited foliar injury surveys may be warranted.

Relevant Websites

NADP - <http://nadp.sws.uiuc.edu/>

CASTNet - <http://www.epa.gov/castnet/>

Ozone - <http://www.epa.gov/airsdata/sources.htm>

IMPROVE - <http://vista.cira.colostate.edu/improve/>

Pollution sources and air quality data - <http://www.epa.gov/air/data/index.html>

Ozone-specific sources and data - <http://www.epa.gov/ttn/rto/areas/>

Pollution source and air quality graphics - <http://www.epa.gov/agweb/>